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IS 7027 (1984): Transistorized Ballasts Fluorescent Lamps
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Indian Standard
SPECIFICATION FOR
TRANSISTORIZED BALLASTS FOR
FLUORESCENT LAMPS
(*First Revision*)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

SPECIFICATION FOR TRANSISTORIZED BALLASTS FOR FLUORESCENT LAMPS

(*First Revision*)

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Indian Standard

SPECIFICATION FOR
TRANSISTORIZED BALLASTS FOR
FLUORESCENT LAMPS
(*First Revision*)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 25 January 1984, after the draft finalized by the Electric Lamps and Accessories Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard was first published in 1973. This revision has been undertaken to take into consideration the developments that have taken place in the field of transistorized ballasts.

0.3 In order to obtain satisfactory performance of fluorescent lamps and transistorized ballasts, it is necessary that certain features of their designs be properly co-ordinated. It is essential, therefore, that specifications for them be written in terms of measurement made against some common base-line of reference, which should be reasonably permanent and reproducible.

0.4 These conditions may be fulfilled by reference ballasts. Moreover, the testing of ballasts for fluorescent lamps will, in general, be made with reference lamps and, in particular, by comparing results obtained on such lamps with ballasts to be tested and with a reference ballast as per IS : 1534 (Part 1)-1977*.

0.5 This standard refers only to transistorized ballasts for use with lamps which are most in demand. Details of sampling and quantitative conditions of compliance are not included.

0.6 The majority of applications for these ballasts are for extra low voltage supplies. It may be expected that ballasts complying with this standard, when associated with lamps which comply with relevant Indian

*Specification for ballasts for fluorescent lamps: Part 1 For switch start circuits (*second revision*).

Standards on fluorescent lamps, will provide satisfactory starting of the lamp at an air temperature immediately around the lamp between 10°C and 35°C at the minimum of the rated voltage range; and operation between 10°C and 50°C within the rated voltage range.

0.6.1 The lamp electrical characteristics, on the lamp data sheets in relevant Indian Standards on fluorescent lamps apply to lamps operated with a reference ballast at its rated voltage, in an ambient temperature of 25°C.

0.7 In the preparation of this standard considerable assistance has been taken from IEC 458 (1982) Transistorized Ballasts for Tubular Fluorescent Lamps issued by the International Electrotechnical Commission.

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS: 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard specifies requirements for transistorized ballasts for use in dc supplies, having rated voltages not exceeding 250 V, associated with fluorescent lamps with pre-heated cathodes, operated without a starter switch and complying with IS : 2418 (Part 2)-1977†.

1.2 These ballasts are suitable for use on maintained and intermittently maintained luminaires for emergency lighting.

1.3 This specification does not apply to transistorized ballasts for railways or for aircraft.

2. TERMINOLOGY

2.0 For the purpose of this standard the following definitions shall apply.

2.1 Transistorized Ballasts — A dc/ac inverter using transistors and other solid state devices which may include stabilizing elements for supplying power to one or more fluorescent lamps.

2.2 Rated Voltage Range — The voltage range marked on the ballast and the range of supply voltage over which the ballast may be operated.

2.3 Design Voltage — The voltage declared by the manufacturer to which all the ballast characteristics are related.

*Rules for rounding off numerical values (revised).

†Specification for tubular fluorescent lamps for general lighting service: Part 2 Standard lamp data sheets (first revision).

2.4 Working Voltage (Symbol U) — The highest rms voltage U which may occur across any insulation, transients being neglected, in open-circuit conditions or during lamp operation.

2.5 Ballast Lumen Factor — The ratio of the light output of the lamp when the ballast under test is operated at its design voltage, compared with the light output of the same lamp operated with the appropriate reference ballast at its rated voltage and frequency.

2.6 Reference Ballast — A special inductive-type ballast (see Appendix A) designed for the purpose of providing comparison standards for use in testing ballasts, and for the selection of reference lamps (see Appendix B). It is essentially characterized by a stable voltage-to-current ratio, which is relatively uninfluenced by variations in current, temperature and the magnetic surroundings, as outlined in these recommendations.

3. SAFETY REQUIREMENTS

3.1 Pulse Voltages

3.1.1 Transistorized Ballasts Intended for Operation from Transient and Surge Free Power Sources, for Example, Leisure Market, Use in Caravans etc. Operated Directly from Batteries Without Charging Equipment — When operating at the maximum voltage in the rated voltage range in association with the appropriate number of lamps and in an ambient temperature of 25°C, the ballast shall withstand, without failing, a number of pulse voltage as given in Table 1 superimposed, with the same polarity, on the supply voltage.

TABLE 1 PULSE VOLTAGES

NUMBER OF VOLTAGE PULSE	PULSE VOLTAGE		PERIOD BETWEEN EACH PULSE
	Peak Value	Pulse Width at Half Peak	
(1)	(2)	(3)	(4)
	V	ms	s
3	Equal to design voltage	10	2

3.1.2 Transistorized Ballasts Intended for Operation from Power Sources to have Attended Transients and Surges, for example, Commercial and Public Transport Vehicles — The test is sub-divided into two sections (a) and (b), both of which are applicable.

- a) *Long duration pulse voltages which, in general, are not likely to be significantly attenuated by conventional inductor/capacitor input filters* — When operating at the maximum voltage of the rated voltage range, in association with the appropriate number of lamps and at an ambient temperature of 25°C, the ballast shall withstand, without failing, a number of pulse voltages as given in Table 2, superimposed with the same polarity on the supply voltage.

TABLE 2 LONG DURATION PULSE VOLTAGES

(Clause 3.1.2)

NUMBER OF VOLTAGE PULSES	PULSE VOLTAGE			PERIOD BETWEEN EACH PULSE
	Peak Value	Pulse Width	Pulse Voltage Rise Time	
(1)	(2)	(3)	(4)	(5)
	V	ms	μ s	s
3	Under consid- eration	500	5 (max)	2

NOTE — The derivation of the values in the above table is explained in Appendix C.

A circuit suitable for producing and applying long duration pulses is shown in Fig. 1.

- b) *Short duration pulse voltages which, in general, are likely to be attenuated by conventional inductor/capacitor input filters* — When operating at the maximum voltage of the rated voltage in association with the appropriate number of lamps and at an ambient temperature of 25°C, the ballast shall withstand, without failing, a number of pulse voltages as given in Table 3 superimposed with the same polarity, on the supply voltage.

TABLE 3 SHORT DURATION PULSE VOLTAGES (10 μ OR LESS)

(Clause 3.1.2)

NUMBER OF VOLTAGE	PULSE VOLTAGE		PERIOD BETWEEN EACH PULSE
	Peak Value	Pulse Energy	
(1)	(2)	(3)	(4)
	V	mJ	s
3	8 times design voltage	1	1

NOTE — The derivation of the values in the above table is explained in Appendix C.

Suitable circuits for measuring pulse power and for producing and applying short duration pulses are shown in Fig. 2 and 3.

3.2 Abnormal Conditions

3.2.1 Removal of Lamp(s) — During operation of the ballast at the maximum value of its rated voltage range and in association with an appropriate lamp(s) the lamp(s) shall be disconnected for 1 h from the ballast without switching off the supply voltage. At the end of this period, the lamp(s) shall be reconnected and shall start and operate normally.

3.2.2 Lamp Fails to Start (Cathodes Intact Electrically) — With an appropriate dummy cathode resistor (according to Table 4) connected in place of each lamp cathode, the ballast shall be operated at the maximum value of its rated voltage range for 1 h. At the end of this period, the resistor shall be removed and an appropriate lamp(s) connected which shall start and operate normally.

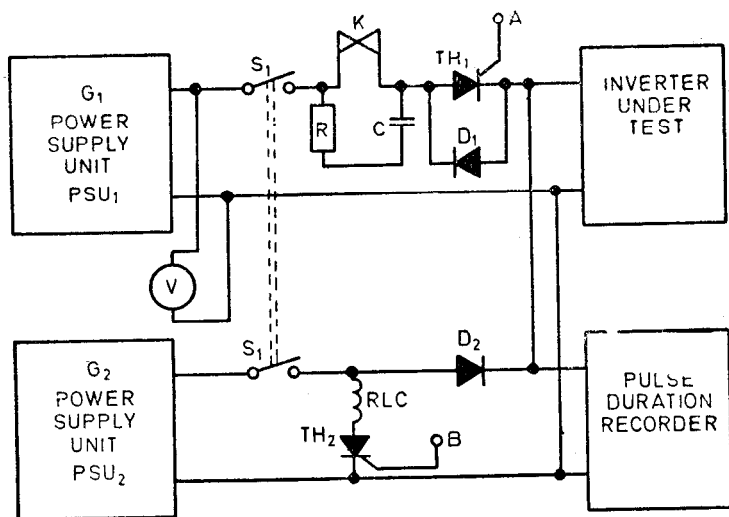
TABLE 4 DUMMY CATHODE RESISTORS

(*Clauses 3.2.2, 5.3.1.1, 5.3.2.1 and 5.3.2.2*)

RATED LAMP WATTAGE	OBJECTIVE RESISTANCE	
	For Lamps with Low Resistance Cathodes	For Lamps with High Resistance Cathodes
(1)	(2)	(3)
<i>W</i>	Ω	Ω
6	9	50
8	9	50
13	9	50
20	9	19
40	9	19

3.2.3 Polarity Reversal — When a ballast is declared to be proof against voltage polarity reversal it shall be tested according to the following:

- a) Ballasts intended for operation from transient and surge-free power sources (*see 3.1.1*) shall be operated with reverse voltage for 1 h, at the maximum voltage of the rated voltage range and with appropriate lamp(s). At the end of this period the supply shall be connected correctly and the lamp shall start and operate normally.



THYRISTOR GATE SIGNALS

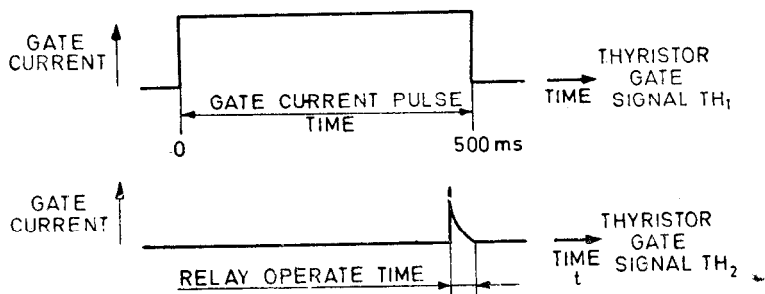


FIG. 1 SUITABLE CIRCUIT FOR PRODUCING AND APPLYING LONG-DURATION PULSES

NOTES ON COMPONENTS

PSU_1 = Power supply unit, capable of supplying maximum pulse voltage required (max. of voltage range + \times design voltage) with pulse current demanded by inverter at this voltage with 2 percent regulation no load to full load.

PSU_2 = Power supply unit adjusted to maximum of input voltage range.

NOTE — Preferably both PSU's should be fitted with current limits to prevent damage in the event of the inverter under test breaking down.

TH_1 = Main switching thyristor used to apply voltage pulse. Many common thyristors should be suitable for this job. They should have a turn on time of about 1 μ s and adequate pulse current capability.

TH_2 = Thyristor controlling the action of the relay RLC.

D = By-pass diode for TH_1 . Allows initial oscillatory transients to operate. Should be fast type (200 ns to 500 ns) with voltage rating equal to $2 \times$ maximum pulse voltage.

D_1 = Blocking diode for PSU_2 . Prevents output impedance of PSU_2 loading voltage pulse source (PSU_1). Should be fast type (approximately 1 μ s turn off) with voltage rating equal to $2 \times$ maximum pulse voltage.

RLC = Pulse termination relay with contacts K .

$R \ \& \ C$ = Spark suppression components. Suggested values are 100 Ω and 0.1 micro Farad (for 26 V inverters).

SI = Switch used as ON/OFF or reset control.

NOTE — The delay system for securing the correct duration of the pulse is not represented on the figure. It should ensure the triggering of thyristor TH_2 500 μ s after the action of TH_1 , account being taken of the operating time of the relay.

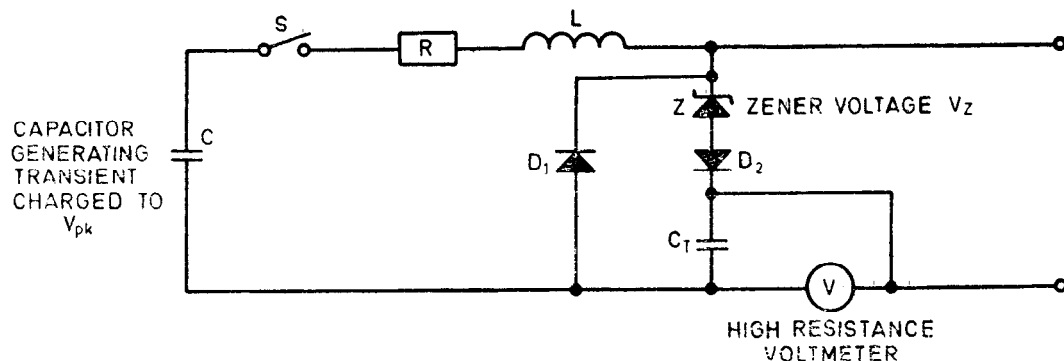


FIG. 2 CIRCUIT FOR MEASURING SHORT-DURATION PULSE ENERGY

NOTES ON COMPONENTS

R = Resistance of the circuit (for the discussion on its value, see Appendix C)

L = Inductance representing the self inductance of the wiring. (It is thus not necessary to materialize it by a separate element in this measuring circuit.)

Z = Zener diode whose voltage V_z is to be chosen as near as possible to the maximum value of the rated voltage range (V_{Max}).

C = Capacitor initially charged to a voltage V_{pk} equal to 8 times the design voltage of the inverter and intended to deliver an energy of 1/mJ in to the diode Z .

As indicated in Appendix C, the value of its capacity is given by:

$$C \text{ (in } \mu\text{F}) = \frac{125}{V_d \cdot V_{\text{Max}}} \text{ or } \left(\frac{100}{(V_d)^2} \text{ if } V_{\text{Max}} = 1.25 V_d \right)$$

C_T = Integration capacitor chosen such that after discharge, the voltage V on it is equal to or less than 1 V.

As indicated in Appendix C, the minimum value of its capacity (corresponding to a voltage V equal to 1 V) is given by

$$C_T \text{ (in } \mu\text{F}) = \frac{1000}{V_{\text{Max}}} \text{ or } \left(\frac{800}{V_d} \text{ if } V_{\text{Max}} = 1.25 V_d \right)$$

D_1 = Reverse current by pass diode, *PIV* rated $20 \times$ design voltage, fast t on and t off 200 ns.

D_2 = Reverse blocking diode, preferably fast turn off with t off 200 ns.

S = ON/OFF switch, blade bounce period, discharge period. Semiconductor switch may be used as an alternative.

V = Voltmeter (normally electronic) with input resistance higher than 10 M Ω .

The following table refers to the most popular design voltages. It gives:

a) The values of capacities C and C_T resulting from the formulae indicated above for the case where $V_{MAX} = 1.25 V_d$.

b) The values of the resistances R securing between the time-constants L/R and RC the relation

$$\frac{L}{R} = 0.05 RC$$

when L is assumed to be 15 μH .

It should be noted that such resistance limit the maximum current to the order of magnitude of 4.5 A.

c) The time-constants RC which allow to assess the order of magnitude of the pulse durations.

COMPONENT VALUES FOR MEASUREMENT OF PULSE POWER

DESIGN VOLTAGE V	CAPACITY C μF	CAPACITY C_T μF	RESISTANCE R Ω	TIME- CONSTANTS RC μs
(1)	(2)	(3)	(4)	(5)
13	0.59	61.5	22.5	13.3
26	0.15	30.8	45	6.7
30	0.04	16	87	3.5
110	0.008 3	7.3	190	1.6

NOTE — As mentioned before, the values of C_T appearing in this table are minimum values. Larger capacities may be used provided that the reading of the voltage V on the voltmeter may still be made in good conditions. If V volts are read, the energy applied to the Zener diode will be given by the expression

$$E_z = C_T V_{c_t} V_z$$

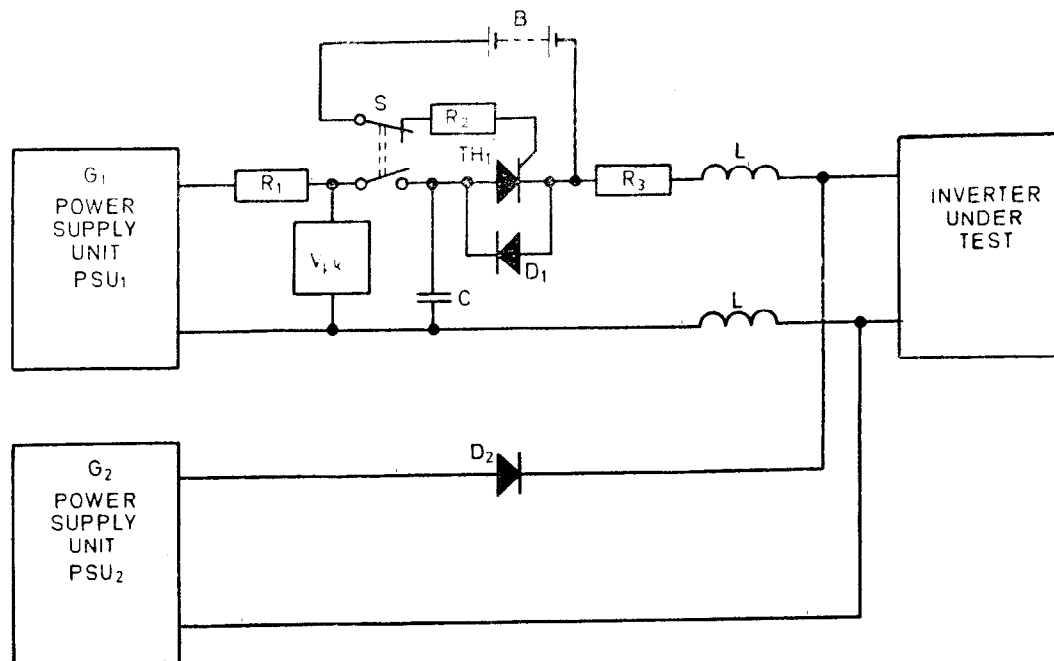


FIG. 3 SUITABLE CIRCUIT FOR PRODUCING AND APPLYING SHORT DURATION PULSES

NOTES ON COMPONENTS

PSU_1 = Power supply unit, capable of charging C to a value = maximum of voltage range + $8 \times$ design voltage.

PSU_2 = Power supply unit, capable of running the inverter under test at the maximum of the design voltage range. Preferably this PSU should be fitted with a current limit.

R_1 = Resistor to limit in rush current to C .

C = Pulse capacitor chosen in accordance with instructions of Fig. 2.

R_3 = Resistance whose value is chosen according to the requirements of Fig. 2.

TH_1 = Main switching thyristor used to apply voltage pulse. Switch on time must be compatible with current pulse rise time.

D_1 = By-pass diode for TH_1 allows initial oscillatory transients to operate. Switch on and off times must be compatible with pulse current rise and on times.

D_2 = Pulse blocking diode for PSU_2 . Turn off time must be compatible with transient pulse width.

R_2 = Gate current limiting resistor.

L = Two inductors to simulate the self-inductance of the wiring of the installation in which the inverter is incorporated.

NOTE — A value of $7 \mu H$ to $8 \mu H$ for each conductor is provisionally specified.

B = Battery to trigger TH_1 typically 7 V dc to 10 V dc.

S = Two pole change-over switch. One position charges C the other triggers TH_1 and discharges C .

V_{pk} = Peak voltmeter (internal resistance) not less than $25 M\Omega$.

- b) Ballasts intended for operation from power sources likely to have attendant transients and surges (see 3.1.2) shall be operated with reverse voltage for 1 h at the maximum voltage of the rated voltage range and with appropriate lamp(s). During this period the ballasts shall withstand, without failing, a number of pulse voltages as specified in Table 3 superimposed, with the same polarity, on the supply voltage. After these tests the supply shall be connected correctly and the lamps shall start and operate normally.

3.3 Terminals for External Wiring — When screw type terminals are provided, they shall comply with the following requirements:

Terminals shall permit the connection of conductors having the following cross-sectional areas:

Terminals for supply wires	0.75 to 2.5 mm ²
Terminals for other external wires	0.5 to 1.5 mm ²

Screw terminals shall be so fixed that when the clamping means are tightened or loosened, they will not work loose; internal conductors are not subject to stress and creepage distances and clearances are not reduced below the values specified in 3.5.

Screw terminals shall be so designed that provision is made for the conductor to be clamped between two metal surfaces and that they allow connection to be made with sufficient contact pressure without damage to the conductor.

A conductor will be considered to be damaged if it shows deep incisions or shearing.

Any terminals for external wiring shall be so placed that when the connection of the conductors is correctly made, there is no risk of accidental contact between live parts of opposite polarity or between such parts and accessible metal parts.

All external terminals shall be so located that the wires can easily be introduced and connected, so that the cover, if any, can be fixed without risk of damage to the wires.

Terminals shall be so designed that the conductor cannot slip out when the screw is tightened. Furthermore, they shall allow a wire to be connected without special preparation (such as, the soldering of the strands of the conductor, use of cable lugs, formation of eyelets, etc).

Requirements for screwless terminals shall be in accordance with IS : 10322 (Part 3)-1984.*

3.4 Provision for Earthing — The earthing terminal (if any) shall be of a type in which the conductor is secured by means of a screw, which shall not work loose in normal use. It shall be placed near to the main terminals in the most convenient position as close to the terminals as possible and its function shall be clearly and durably marked with the symbol \perp .

This symbol shall not be placed on screws, removable washers or other easily removable parts. It shall also be in effective electrical contact with all exposed metal parts and comply with the requirements of 3.3. The metal of the earthing terminal shall be such that no corrosion shall occur resulting from contact with the copper of the earthing conductor.

The screw of the other parts of the earthing terminal shall be made of brass or other non-rusting material and the contact surfaces shall be bare metal. If iron parts are used, corrosion of these parts shall be prevented. It shall not be possible to loosen the earthing terminal screw without the aid of a tool.

NOTE — In some instances, starting aids adjacent to the lamp(s), are connected to one of the output terminals but are not connected to the earth on the supply side.

3.5 Creepage Distance and Clearances — Creepage distances and clearances shall be not less than the values given in Table 5.

With the exception of printed wiring boards (print plates) which are exempt from the requirements of this sub-clause, each of the creepage distances and clearances which are less than those given in Table 6 shall be short circuited in turn. Under these conditions safety shall not be impaired.

NOTE — Creepage distances are measured along the external surface of the insulating material.

The contribution of the creepage distance of any groove less than 1 mm wide shall be limited to its width.

Any air-gap of less than 1 mm shall be ignored in computing the total air path.

*Specification for luminaires: Part 3 Screw and screwless terminals.

TABLE 5 CREEPAGE DISTANCES AND CLEARANCES IN AIR

(Clause 3.5)

Sl No.	WORKING VOLTAGE	UP TO AND INCLUDING 34 V	ABOVE 34 V UP TO AND INCLUDING 250 V	ABOVE 250 V UP TO AND INCLUDING 500 V
(1)	(2)	(3)	(4)	(5)
		mm	mm	mm
i)	Creepage distance and clearance			
	1. Between live parts of different polarity	2	3(2)	5(3)
	2. Between live parts and accessible metal parts which are permanently fixed to the ballast, including screws or devices for fixing covers or fixing the ballast to its support	2	4(2)	6(3)
ii)	Clearance			
	3. Between live parts and a flat supporting surface or a loose metal cover, if any, if the construction does not ensure that the values under 2 above are maintained under the most unfavourable circumstances	2	6	10

NOTE 1 — The values within brackets apply to creepage distances and clearances completely protected against dirt. Completely sealed-off or compound-filled distances are not checked.

NOTE 2 — The working voltage is the highest dc or rms voltage which may occur across any insulation, transients being neglected, in open-circuit conditions or during lamp operations.

A metallic enclosure shall have an insulating lining if, in the absence of such a lining, the creepage distances or clearances between the live parts and the enclosure is smaller than the value specified above.

3.6 Protection Against Accidental Contact — The enclosure of independent ballasts shall not have any opening giving access to live parts other than those necessary for the use and working of the ballast.

In addition, ballasts shall be so constructed that when installed as in normal use, they are sufficiently protected against accidental contact with live parts having voltages with respect to earth greater than 50 V.

Lacquer or enamel is not deemed to be adequate protection or insulation for the purpose of these requirements.

Parts providing protection against accidental contact shall have adequate mechanical strength and shall not work loose in normal use. It shall not be possible to remove them without the aid of a tool.

Compliance shall be checked by inspection and, if necessary, by a test with the standard test finger shown in Fig. 7 of IS : 1913 (Part 1)-1978*. This test finger is applied in every position, if necessary with a force of 30 N, an electrical indicator being used to show contact with live parts.

It is recommended that a lamp be used for the indication of contact and that the voltage be not less than 40 V.

NOTE — Requirements for radio interference and acoustic noise are under consideration.

4. MARKING

4.1 The ballasts shall be indelibly marked with the following information:

- a) Name of the manufacturer or trade-name, if any;
- b) Country of manufacture;
- c) Type;
- d) Wiring diagram indicating the position of terminals. In the case of ballasts not having terminals, a clear indication shall be given on the wiring diagram of the significance of the code used for the connecting wires;
- e) Rated supply current range for the maximum permissible lamp load and rated voltage range;

NOTE — Ballasts designed to operate varying numbers and ratings of lamps draw different supply currents at the same supply voltage.

- f) Rated wattage and if necessary, the designation of the type(s) of lamp(s) for which the ballast is designed. If the ballast is to be used with more than one lamp, the number and wattage of each lamp is to be indicated.
- g) Rated operating frequency (at design voltage with lamps alight); and
- h) Open circuit voltage and voltage to earth if greater.

*Specification for general and safety requirements for luminaires: Part 1 Tubular fluorescent lamps (*second revision*).

4.1.1 In addition the following information shall be made available by the manufacturer:

- a) Design voltage;
- b) Declared light output (percent);
- c) Heat sink(s) required additional to ballast;
- d) Maximum permissible case temperature, and position of measurement, when operated with lamp(s) alight and at the maximum voltage of the rated voltage range;
- e) Whether the ballast is suitable for use only on battery supplies not having a trickle or intermittent recharging circuit; and
- f) Whether the ballast is proof against supply voltage polarity reversal.

4.1.2 The ballast may also be marked with the Standard Mark.

NOTE — The use of the Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

5. TESTS

5.1 Classification of Tests

5.1.1 Type Tests — The following shall constitute the type tests:

- a) Visual examination (*see 5.2*),
- b) Performance requirements test (*see 5.3*),
- c) Endurance test (*see 5.4*),
- d) Insulation resistance test (*see 5.5*), and
- e) Electric strength test (*see 5.6*).

5.1.2 Acceptance Tests — (under consideration).

5.1.3 Routine Tests — (under consideration).

5.2 Visual Examination — The ballast shall be examined visually for good workmanship.

5.3 Performance Requirements Test

5.3.0 Test shall be made under the conditions specified in Appendix D.

5.3.1 Open-circuit Voltage at Terminations of Lamp — A ballast when operated at any voltage within its rated voltage range shall provide and open-circuit voltage at the lamp termination such that:

- The minimum rms voltage across the lamp is at least that shown in col 3 of Table 6.
- The peak voltage across the lamp does not exceed that shown in col 4 or 5 of Table 6.
- The minimum peak voltage from one end of the lamp to the starting aid is at least that shown in the col 6 of Table 6.

When ballasts are designed to operate lamps in parallel circuits, the relevant requirements shall be met for each separate lamp, independent of the number of inserted lamps.

Lamps operated with transistorized ballasts complying with this standard require a starting aid as specified in relevant Indian Standards on fluorescent lamps except in the case of lamps with bulb diameter 16 mm *Max*, where the starting aid shall be positioned 7 mm from the lamp.

TABLE 6 OPEN-CIRCUIT VOLTAGE FOR LAMP WITH EITHER HIGH OF LOW RESISTANCE CATHODES

RATED LAMP WATTAGE	NOMINAL DIMENSIONS	OPEN-CIRCUIT VOLTAGE AT LAMP TERMINATIONS			VOLTAGE TO STARTING AID
		Min	Peak Voltage		
			Symmetri- cal inverter	Asymmetri- cal inverter	
(1) W	(2) mm	(3) Vrms	(4) V Peak	(5) V Peak	(6) V Peak
6	224×15	100	550	700	290
8	300×15	100	550	700	290
13	525×15	200	550	700	290
15T8	450×25	180	550	700	260
20	590×38	180	550	700	260
30T8	900×25	205	550	700	300
30T12	900×38	200	550	700	290
40	1 200×38	205	550	700	300

5.3.1.1 During these tests each lamp cathode shall be replaced by a resistor having a value in accordance with Table 4.

NOTE — The maximum values in Table 6 are higher than those recommended in IS : 2418 (Part 2)-1977* because of the greater voltage range of the supply voltage; this may lead to a decreased lamp life performance.

*Specification for tubular fluorescent lamps for general lighting purposes: Part 2 Standard lamp data sheets (*first revision*).

5.3.2 Per-heat Conditions

5.3.2.1 Minimum voltage across lamp cathode — With a resistor of the objective value specified in Table 4 substituted for each lamp cathode and when operated at any voltage within the rated voltage range, the ballast shall deliver a voltage at each resistor of at least 3.05 V rms for low resistance cathode lamps and of at least 6.5 V rms for high resistance cathode lamps.

5.3.2.2 Maximum voltage across lamp cathode

- a) *Ballasts for lamps with low resistance cathodes* — With a resistor of the objective value specified in Table 4 substituted for each lamp cathode and when operated at any voltage within the rated voltage range, the ballast shall deliver a voltage at each resistor not exceeding 6.5 V rms.
- b) *Ballasts for lamps with high resistance cathodes* — With a resistor of the objective value specified in Table 4 substituted for each lamp cathode and when operated at any voltage within the rated voltage range, the ballast shall deliver a voltage at each resistor not exceeding 11.0 V rms.

However, in those cases where this voltage does exceed 10.0 V rms a regulation check shall be made using a resistor of the value specified in Table 7 substituted for each lamp cathode and when the ballast is operated at any voltage within its rated voltage range, the current passed through each resistor shall not exceed the appropriate value shown in the col 3 of Table 7.

TABLE 7 REGULATION CHECK RESISTORS

RATED LAMP WATTAGE	REGULATION CHECK RESISTORS OBJECTIVE RESISTANCE	MAXIMUM CURRENT IN REGULATION CHECK RESISTOR
(1)	(2)	(3)
W	Ω	A rms
6	31	0.34
8	31	0.34
13	31	0.34
20	14	0.76
40	12	0.88

5.3.3 Lamp Current and Luminous Flux — The ballast shall limit the arc current delivered to a reference lamp to a value not exceeding 125 percent of the delivered to the same lamp when operated with a reference ballast. The ballast under test shall be operated at its rated design voltage and the appropriate reference ballasts shall be operated at its rated voltage and frequency in accordance with Appendices A and B, respectively.

Under the same conditions, the ratio of the luminous flux shall not be less than the ballast lumen factor.

NOTE — Any test circuit corresponding to that of Fig. 4, can be used to make the measurement.

5.3.4 Current Drawn from Supply — At the design voltage, the current drawn from the supply shall not differ by more than ± 15 percent from the value marked on the ballast when the latter is operated with a reference lamp.

Under the same conditions, and with the addition of a non-inductive resistor in series with the input to the ballast, any rms alternating current component of the dc input current shall not exceed 10 percent. The dc voltage drop in the resistor shall not exceed 2 percent of the design voltage.

5.3.5 Maximum Current in any Lead to a Cathode — With an appropriate reference lamp in circuit and with the ballast in normal operation and at a supply voltage equal to the maximum of the rated voltage range the current flowing in any one of the cathode terminations shall not exceed the value indicated in Table 8.

**TABLE 8 MAXIMUM CURRENT IN ANY LEAD TO A CATHODE
(LOW AND HIGH-RESISTANCE CATHODES)**

RATED LAMP WATTAGE	CURRENT, <i>Max</i>
(1)	(2)
<i>W</i>	<i>A</i>
6	0.28
8	0.25
13	0.29
20	0.65
40	0.75

5.3.6 Lamp Operating Current Wave-Shape — The waveform of the current supplied in the steady state to a reference lamp, associated with a ballast supplied at its design voltage, shall be such that the maximum ratio of peak value to root-mean-square (rms) value shall not exceed 1.7.

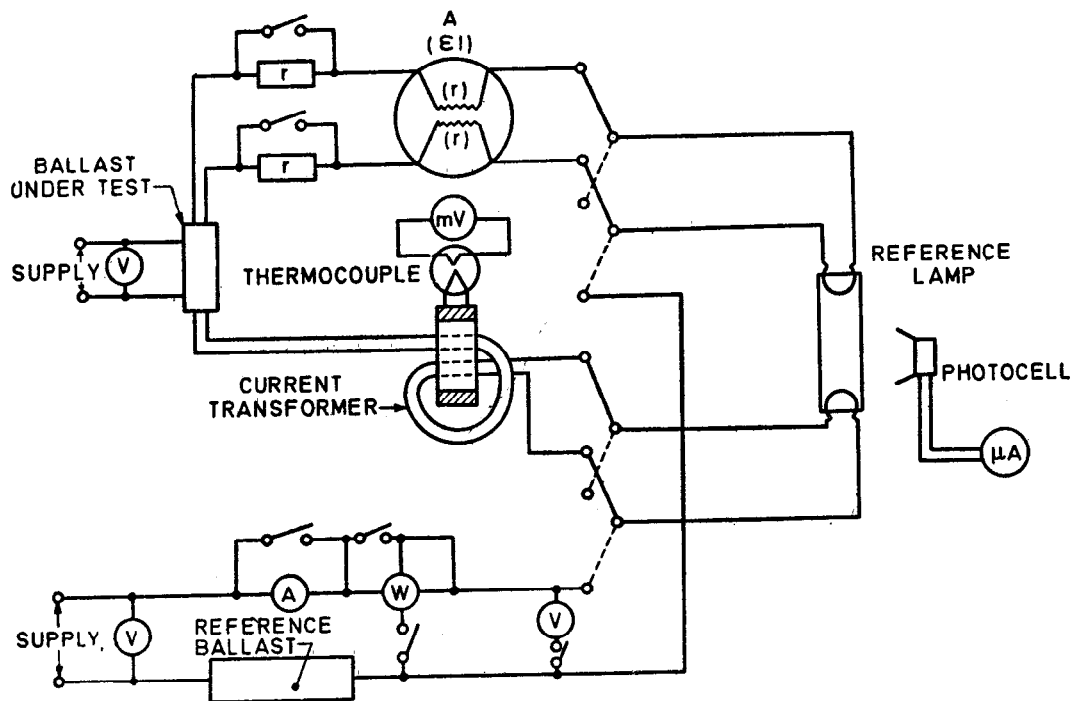


FIG. 4 SUITABLE CIRCUIT FOR THE MEASUREMENT OF LAMP CURRENT AND LUMINOUS FLUX

5.4 Endurance Test — The ballast shall be mounted in accordance with the manufacturer's instructions (including heat sink, if specified) and operated in association with an appropriately rated lamp(s) at the maximum voltage of the rated voltage range, and in an ambient temperature $t^{\circ}\text{C}$, such that the maximum permissible case temperature is reached [see 4.1.1 (d)].

The ballast shall then be operated in an ambient temperature which shall be varied from $t_{Min} = (t - 5) \pm 2^{\circ}\text{C}$ to $t_{Max} = (t + 10) \pm 2^{\circ}\text{C}$ t_{Max} . and t_{Min} , shall be maintained for 1 h.

After five such cycles, the ambient temperature shall be maintained at t_{Max} . until a total test period of 200 h has passed. At the end of this time, and after cooling to room temperature, the ballast shall not show any deterioration impairing safety.

The total test period shall be as follows:

For ballasts for maintained emergency lighting	500 h
For all other ballasts	200 h

All ballasts marked for emergency lighting use shall restart and operate the lamps at the design voltage of the ballast.

5.5 Insulation Resistance Test — The insulation resistance of the ballast shall be measured with an applied voltage of approximately 500 V dc for not more than 1 min as follows:

- Between the input terminals bonded together and all exposed metal parts, the output terminal being open-circuit, and
- Between the output terminals bonded together and all exposed metal parts, the input terminals being open-circuit.

The insulation resistance shall not be less than 2 M Ω in each test.

In the case of ballasts having an internal connection between one or more output terminals and the earth terminal, such a connection shall be removed during this test.

5.6 Electric Strength Test — The ballast shall withstand the following test:

An externally produced voltage of $(2U + 1\,000)$ V ac 50 Hz shall be connected for 1 min between any of the output terminals and all exposed metal parts, the input terminals shall be short-circuited and any built-in capacitor for radio interference suppression which is connected between the earth side of the system and the housing shall be disconnected. The test voltage shall be applied gradually but rapidly.

In the case of ballasts having an internal connection between one or more output terminals and the earth terminal, such a connection shall be removed during this test.

APPENDIX A

(Clause 2.6)

REFERENCE BALLAST

A-1. When measured in accordance with the requirements for reference ballasts given in IS : 1534 (Part 1)-1977*, the reference ballasts shall have the characteristics specified in IS : 1534 (Part 1)-1977* as well as those specified in the appropriate lamp data sheets given in IS : 2418 (Part 2)-1977†.

APPENDIX B

(Clause 2.6)

REFERENCE LAMPS

B-1. Reference lamps shall be measured and selected as outlined in IS : 1534 (Part 1)-1977* and have the characteristics specified on the appropriate lamp data sheets in IS : 2418 (Part 2)-1977†.

APPENDIX C

(Clause 3.1.2)

EXPLANATION OF THE DERIVATION OF THE VALUES OF PULSE VOLTAGES GIVEN IN 3.1

C-1. The voltage rise time specified in Table 2 is intended to shock excite the input filter of the inverter and produce a 'worst case' effect. The time of $5\text{ }\mu\text{s}$ is chosen to be less than the rise time of a very poor input filter $T = \pi\sqrt{LC}$, L = input filter inductor, C = inverter filter/reservoir (capacitor).

*Specification for ballasts for fluorescent lamps: Part 1 For switch start circuits (*second revision*).

†Specification for tubular fluorescent lamps for general lighting service: Part 2 Standard lamp data sheets (*first revision*).

C-2. The peak pulse voltage in Table 5E is given as X times the design voltage. For 13 V and 26 V inverters this gives a voltage applied to the inverter as follows:

$$\begin{aligned} (13 \times X) + 15 (\text{Max of voltage range}) &= Y \\ \text{and } (26 \times X) + 30 (\text{Max of voltage range}) &= Z \\ (\text{Values for } X, Y \text{ and } Z \text{ are under consideration}) \end{aligned}$$

C-3. The peak pulse voltage in Table 3 is given as 8 times the design voltages. For 13 V and 26 V inverters this gives a voltage applied to the inverter as follows:

$$\begin{aligned} (13 \times 8) + 15 (\text{Max of voltage range}) &= 119 \text{ V} \\ \text{and } (26 \times 8) + 30 (\text{Max of voltage range}) &= 238 \text{ V} \end{aligned}$$

C-4. Explanations referring to the choice of values for the components of the 'circuit for measuring pulse energy' illustrated in Fig. 2 are:

The discharge must be periodic in order that the Zener diode receives one pulse only. Consequently, the resistance R shall be sufficiently large to ensure that:

- The influence of the self inductance loop in the circuit, due to wiring, is sufficiently small; this implies that the time-constant L/R be definitely smaller than the time constant RC .
- The maximum value of the current [which may be assessed by $(V_{pk} - V_z)/R$] should be compatible with the good operation of the Zener diode.

On the other hand, this resistance R should not be too large if the pulse has to remain short enough.

With a total inductance of $14 \mu\text{H}$ to $16 \mu\text{H}$ (as indicated in the notes under Fig. 3) and the values for C indicated below, it appears that the previous conditions may be fulfilled with values of R of the order of magnitude of 20Ω for an inverter whose design voltage is 13 V rising to about 200 V for a design voltage of 110 V.

It should be noted that it is not necessary to insert a separate inductance L in the circuit of Fig. 2.

Assuming an aperiodic discharge, the value of the capacity C is related to the energy E_z applied to the Zener diode (which takes the place of the inverter) and to the voltages involved by the expression:

$$C = \frac{E_z}{(V_{pk} - V_z - V_{c_t})V_z}$$

where

V_{pk} = voltage initially applied to capacitor C ,

V_z = voltage of the Zener diode, and

V_{c_t} = final voltage on capacitor C_T .

Let

V_d design voltage of the inverter to be tested, and

V_{Max} maximum value of its rated voltage range ($1.25 V_d$).

We take

$V_z = V_{Max}$ (the best possible approximation).

$V_{pk} = 8 V_d + V_{Max}$.

and, moreover, V_{c_t} will remain equal to or less than 1 V.

This last condition allows to neglect this voltage V_{c_t} with respect to the difference ($V_{pk} - V_z$) and one may thus write

$$C = \frac{E_z}{(V_{pk} - V_z) \times V_z}$$

With the values for the voltages indicated above and with the prescribed condition $E_z = 1 \text{ mJ}$, the expression of C becomes

$$C (\mu F) = \frac{125}{V_d - V_{Max}}$$

On the other hand, a minimum value for the capacity C_T may be computed starting from

$$E_z = C_T V_{c_k} V_z$$

and adopting 1 mJ for E_c and 1 V for V_{c_t} , we are led to

$$C_T (\mu F) = \frac{1000}{V_{Max}}$$

Considering the case with $V_{Max} = 1.25 V_d$, the values of capacities C and C_T may then be expressed in function of the sole voltage V_d as follows:

$$C (\mu F) = \frac{100}{(V_d)^2}$$

and

$$C_T (\mu F) = \frac{800}{V_d}$$

APPENDIX D

(Clause 5.3.0)

TEST CONDITIONS

D-1. GENERAL REQUIREMENTS — Tests are type tests. One sample shall be submitted to all tests.

D-1.1 Ambient Temperature — Tests shall be made in a draught-free room and at an ambient temperature within the range 20 to 27°C.

For those tests which require constant lamp performance, the ambient temperature around the lamp shall be within the range 23 to 27°C and shall not vary by more than 1°C during the test.

D-1.2 Supply Voltage and Frequency

- a) *Test Voltage and Frequency* — Unless otherwise specified, the ballast to be tested shall be operated at its design voltage and the reference ballast at its rated voltage and frequency.
- b) *Stability of Supply and Frequency* — For the majority of the tests, the supply voltage and where appropriate for the reference ballasts, the frequency, shall be maintained constant within ± 0.5 percent. However, during the actual measurement, the voltage shall be adjusted to within ± 0.2 percent of the specified testing value.
- c) *Supply Voltage Waveform for Reference Ballasts Only* — The total ripple content of the supply voltage shall not exceed 3 percent, ripple content being defined as the root-mean-square (rms) summation of the individual components using the fundamental as 100 percent.

D-1.3 Magnetic Effects — Unless otherwise specified, no magnetic object shall be allowed within 25 mm of the face of the reference ballast or the ballast under test.

D-1.4 Mounting and Connection of Reference Lamps — In order to make the reference lamps repeat their electrical values with the greatest consistency, it is recommended that the lamps be mounted horizontally and allowed to remain permanently in their test lampholders. So far as the identification of ballast terminals will permit, reference lamps should be connected in circuit maintaining the polarity of the connections used during ageing.

D-1.5 Reference Lamp Stability

- a) A lamp shall be brought to a condition of stable operation before carrying out measurement. No swirling shall be present.
- b) The characteristics of a lamp shall be checked immediately before and immediately after each series of tests.

D-1.6 Instrument Characteristics

- a) *Potential Circuits* — Potential circuits of instruments connected across the lamp shall not pass more than 3 percent of the nominal running current.
- b) *Current Circuits* — Instruments connected in series with the lamp shall have a sufficiently low impedance such that the voltage drop shall not exceed 2 percent of the objective lamp voltage.

Where measuring instruments are inserted into parallel heating circuits, the total impedance of the instruments shall not exceed 0.5.

- c) *rms Measurements* — Instruments shall be essentially free from errors due to waveform distortion.

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